



Project X Research, Design, and Development Plan

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FRA Physics Visiting Committee
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Project X RD&D Program Goals



- The goal of the Project X RD&D program is to provide support for a Critical Decision 1 (CD-1) in 2010, leading to a CD-2/3a in 2011.
 - Design and technical component development;
 - Development of all project documentation mandated by DOE 413.3;
 - Formation of a multi-institutional collaboration capable of executing both the R&D plan and the provisional construction project.
- The primary technical goal is completion of a Conceptual Design Report, followed by a fully developed baseline cost estimate and schedule, and supported by a technology development program.
 - Capability of delivering in at least 2 MW of beam power over the range 60 - 120 GeV, simultaneous with at least 200 kW of beam power at 8 GeV.



Project X RD&D Technical Goals



- Complete conceptual design and cost estimate for Project X:
 - technical and conventional construction elements,
 - systems integration, and
 - installation and commissioning plan.
- Supporting technology development program targeting key accelerator physics and engineering challenges
 - incorporating simulations, experiments, and prototype construction as appropriate.
- Alignment with the SRF/ILC program:
 - Primary goal is to develop a set of technologies applicable to both ILC and Project X
 - Common cavity/cryomodule design, rf sources, tunnel layout
 - Project X linac designed to accommodate accelerating gradients in the range 23.6 - 31.5 MV/m (XFEL - ILC)
 - Final design gradient determined prior to CD-2.



Steps in Developing the RD&D Plan



- **Project Requirements** - Receive the general requirements that support the desired physics
 - Derived from the Nov. 2007 & Jan 2008 Physics workshops
 - Director's Guidance
- **Scope** - Determine the scope of the project that meets the project requirements
- **System Requirements** - develop major system requirements
 - 10 major systems
 - 17 base requirements
 - 68 derived requirements
- **Issues** - discuss issues arising from the requirements
- **Elements** - define the elements of an RD&D plan that
 - Addresses the issues arising from the requirements
 - Are directed towards a completion of Conceptual Design Report
- **Resources and Schedule** - estimate:
 - The resources required to complete the R&D plan
 - The schedule required to complete the R&D plan



Project X Requirements



Req. No.	Description	Req.	Unit
1.0	General		
1.1	120 GeV Beam Power	2.3	MW
1.2	8 GeV Beam Power	360	kW
1.3	8 GeV Slow Spill Beam Power	200	kW
1.4	8 GeV Slow Spill Duty Factor	55	%
1.5	120 GeV Availability	75	%
1.6	8 GeV Availability	80	%
1.7	Upgradeable 8 GeV Beam Power for Civil, RF, & Cryo Systems	2	MW

■ Notes:

- Availability is defined as the percentage time that the complex is delivering beam
- 8 GeV duty factor is the result of slow spill being done in the Recycler



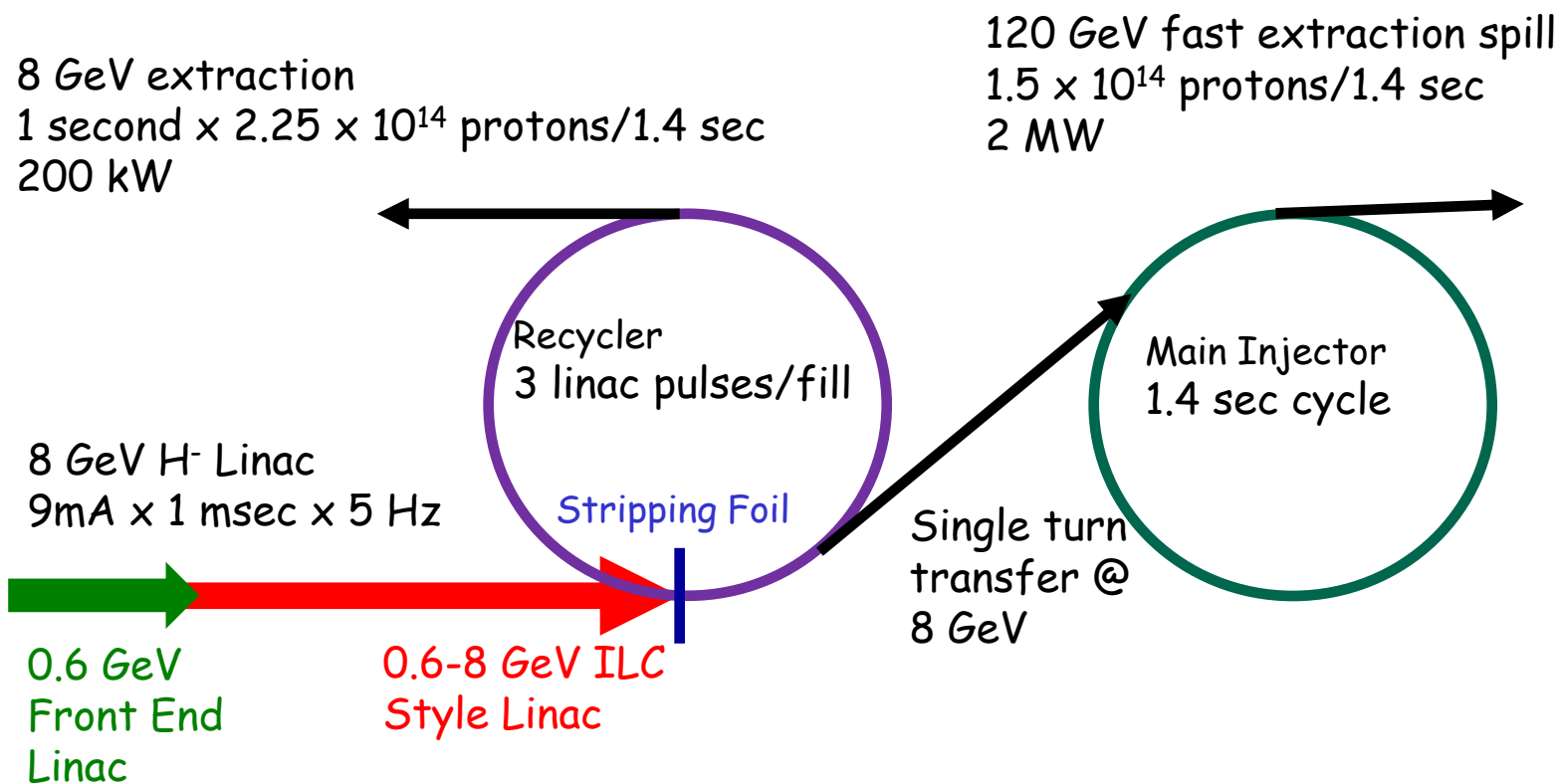
Project X Scope



- The basic scheme of Project X is:
 - An 8 GeV Linac operating at ILC-like parameters
 - H- stripping and proton accumulation in the Recycler
 - Beam distributed to the Main Injector for acceleration to 120 GeV
 - Beam distributed to an 8 GeV slow spill program
- The major components that comprise Project X are:
 - A front end linac operating at 325 MHz (max energy 600MeV).
 - An ILC-like linac operating at 1300MHz.
 - An 8 GeV transfer line and H- Injection system.
 - The Recycler operating as a stripping ring and a proton accumulator.
 - The Main Injector acting as a rapid cycling accelerator.
 - A slow extraction system from the Recycler.
 - 120 GeV Neutrino beamline.
 - Civil Construction and Utilities
 - Controls
 - Cryogenics



Project X Scope





Previous Work on Project X Scope



- Project X Preliminary Report - August 1, 2007
 - Delivered to Fermilab Directorate Long Range Steering committee
 - Fermilab Accelerator Advisory Committee
 - "We congratulate the Project X team on an innovative design"
 - "Project-X is especially suitable for Fermilab in the current scenario of a not well-defined schedule of ILC construction, because of synergies with ILC. "
 - "The committee therefore very strongly supports the work that is planned for Project-X."
 - <http://projectx.fnal.gov/AACReview/ProjectXAacReport.pdf>
- Project X Accelerator Physics and Technology Workshop - Nov. 12, 2007
 - attended by 175 people from 28 different institutions.
 - The workshop report can be found at:
 - <http://projectx.fnal.gov/Workshop/ProjectXWorkshopReport.pdf>



Collaboration with Other Institutions



- The intention is to organize and execute the Project X R&D Program via a multi-institutional collaboration, drawing significant participation from outside of Fermilab.
- The goal is to give collaborators complete and contained sub-projects, meaning
 - they hold responsibility for Design, Engineering, and estimating
 - and potentially construction if/when Project X proceeds.
- FNAL project responsibility → overall coordination and organization of appropriate technical & cost reviews
- Collaboration Structure is outlined in the Project X Research, Design, and Development Plan. The plan can be found at:
 - <http://projectx.fnal.gov/RnDplan/index.html>
- Some initial expressions of interests from other institutions were discussed at the Project X Accelerator Physics and Technology Workshop - Nov. 12, 2007
 - attended by 175 people from 28 different institutions.
 - The workshop report can be found at:
 - <http://projectx.fnal.gov/Workshop/ProjectXWorkshopReport.pdf>



Project X Related Programs & Deliverables



- High Intensity Neutrino Source (HINS)
 - Bob Webber (APC)
 - Project X related deliverable: Prototype a 66 MeV Linac operating at 325 MHz providing 27mA of beam with a 1 mS pulse length
- Superconducting RF Infrastructure
 - Kephart (Directorate), Mishra (TD/Dir), Nagaitsev (AD/Dir)
 - Project X related deliverables:
 - Develop 1 cryo-module/ month capability
 - Three $\beta=1$ ILC-like cryo-modules
 - NML RF unit test facility & CM test stand
 - System Integration test of ILC Cryo RF unit
- ILC Americas
 - Cavities and processing: Mark Champion (TD)
 - Cryomodule design & assembly: Carter (TD)



Project X Major System Requirements



- Once the scope of Project X was defined, a Fermilab team was formed to develop the major system requirements of Project X
- Fermilab Team:
 - Project Leader: Dave McGinnis (AD/RF)
 - Deputy Project Leader: Elaine McCluskey (AD/HQ)
 - 325 MHz Linac: Bob Webber (APC)
 - 1300MHz Linac: Sergei Nagaitsev (AD/HQ)
 - 8 GeV Injection System: Dave Johnson (APC)
 - Recycler Ring: Paul Derwent (AD/RR)
 - Main Injector: Ioanis Kourbanis (AD/MI)
 - 8 GeV Slow Extraction: Eric Prebys (AD/PS)
 - 120 GeV Targeting: Mike Martens (AD/EB)
 - Civil Construction and Utilities: Elaine McCluskey (AD/HQ)
 - Controls: Jim Patrick (AD/CD)
 - Cryogenics: Arkadiy Klebaner (AD/Cryo)



System Requirements



Major system requirements

- 10 major systems
- 17 base requirements
- 68 derived requirements

Examples of Major system requirements

Req. No.	Description	Req.	Unit	Reference Requirements			
2.0	325 MHz Linac						
2.1	Average Beam Current	9	mA	1.2			
2.2	Pulse Length	1	mS	1.2			
2.3	Repetition rate	5	Hz	1.2			
2.4	325 MHz Availability	98	%	1.6			
2.5	Peak RF Current	14.4	mA	2.1	2.11	2.13	2.14
2.6	Final Energy	420	MeV	3.6			
2.7	Energy Variation (rms)	1	%	3.10			
2.8	Bunch Phase jitter (rms)	1	degree	3.11			
2.9	Linac Species	H-		4.1			
2.10	Transverse Emittance (95% normalized)	2.5	π -mm-mrad	5.7	5.8		
2.11	Macro Bunch Duty Factor	67	%	5.10	5.12		
2.12	Macro Bunch Frequency	53	MHz	5.12			
2.13	Micro Pulse Length	10.4	μ S	5.13			
2.14	Micro Pulse Period	11.1	μ S	5.13			

Req. No.	Description	Req.	Unit	Reference Requirements			
4.0	8 GeV Transfer Line						
4.1	Injection Stripping efficiency	98	%				
4.2	Length (approx.)	1000	meters				
4.3	Maximum average activation level	20	mrem/hr				
4.4	Availability	98	%	1.6			
4.5	Momentum Aperture	+/- 0.8	%	3.10			
4.6	Minimum Transverse Aperture	25	π -mm-mrad	3.13	4.3		
4.7	Maximum Dipole Field	0.05	T	4.1	4.3		
4.8	Transfer Efficiency	99.99	%	4.3			
4.9	Final Energy Variation	+/- 0.11	%	5.10			
4.10	Energy	8	GeV	5.1			



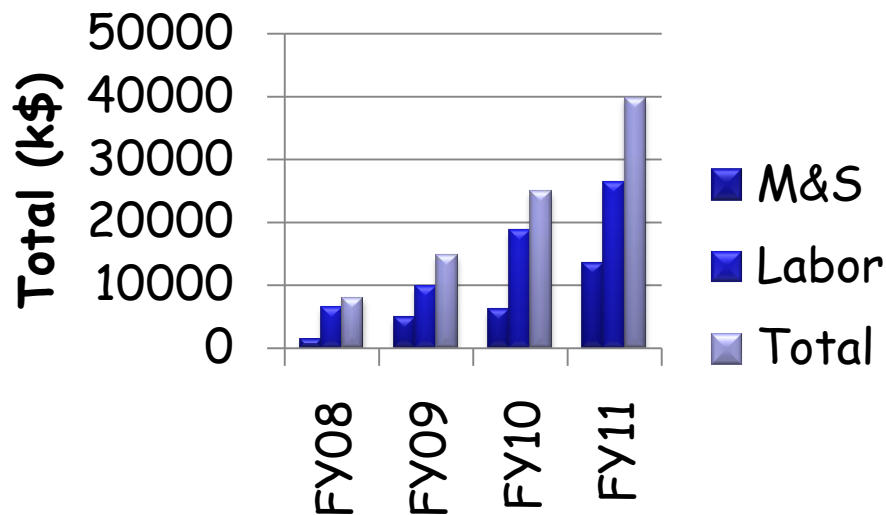
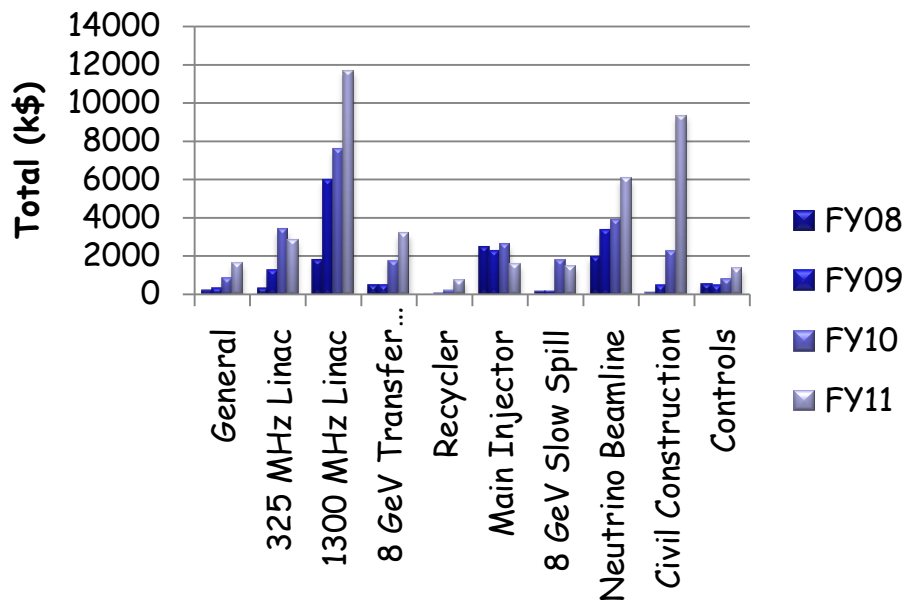
RD&D Plan Write-up



- Once the major system requirements were formulated, a report was written that
 - Discussed issues arising from the requirements
 - Defined the elements of an RD&D plan that
 - Addresses the issues arising from the requirements
 - Are directed towards a completion of Conceptual Design Report
 - Estimated:
 - The resources required to complete the R&D plan
 - The schedule required to complete the R&D plan
- The plan is documented at:
 - <http://projectx.fnal.gov/RnDplan/index.html>



RD&D Plan Resource Requirements



		All		
		Total	Labor	M&S
		k\$	FTE	k\$
		(unburd.)		
1	General	3009	33	0
2	325 MHz Linac	7809	40	1140
3	1300 MHz Linac	27022	130	6045
4	8 GeV Transfer Line	5942	41	100
5	Recycler	943	6	95
6	Main Injector	8890	49	2925
7	8 GeV Slow Spill	3452	28	0
8	Neutrino Beamline	15221	72	4440
9	Civil Construction	12107	15	6705
10	Controls	3134	14	75
Total		87527	428	21525



Project X RD&D Plan for FY08



- The main goal for the Project X RD&D Plan for FY08 is
 - to get an initial cost estimate for Project X for CD0.
 - Begin on long-term R&D items
- To prepare an initial cost estimate for CD0, the design of Project X must be further developed.
- To organize the labor resources in FY08, each level 2 manager reviewed the FY08 goals formulated in the RD&D plan.



Project X FY08 Resources



- For each FY08 goal, each level 2 manager was asked to provide a bottoms-up estimate of effort required, to include:
 - A list of names of people that would be best suited to accomplish the goal.
 - Note: We have not talked to the division heads or department heads if this person is available.
 - With each name there should be a description of the task the person is to do.
 - How much percentage effort the person will expend.
 - The duration of the task.
- The resource information was loaded into the Project X WBS using OHAP resource types, and summarized to provide an overall look at Project X 08 labor requirements
- In parallel, the related program labor effort (HINS, SCRF, NML) was tallied for a “big picture” summary



Example Project X FY08 Goals



- 325 MHz Linac
 - Begin basic accelerator physics design of the Linac
 - Organize documentation of the present "Ostroumov" machine design and summarize current state of simulations
 - Define the high-level, implementation-independent specifications for the linac beam including upgrade paths that must be not excluded
 - Define the beam physics parameter interface between the Low Energy Linac and the High Energy Linac
 - Begin HINS vs. alternative technology study
- 1300 MHz Linac
 - Physics Design: Establish beam requirements, design parameters, lattice model, interfaces to other Project x areas and on beam loss budget.
 - Linac technical design: Conceptual design of S-ILC cavities and cryomodules, magnets, instrumentation, and vacuum systems.
 - RF Power Systems: Determine requirements, initiate conceptual studies.
 - Integration: Initiate conceptual design of controls, LLRF, HLRF, civil, machine protection integration.
 - System Tests: Initiate conceptual design of RF unit system test.



Example Project X FY08 Goals



- Recycler
 - Lattice flexibility options, in terms of distributed powered elements, be studied and completed.
 - Anticipate specifications on magnets/power supplies
 - Electron Cloud investigations: Begin studying mitigation methods specific to the Recycler such as beam pipe coating.
 - Begin simulation investigations of electron cloud by concentrating on the validation of a simulation package.
- Main Injector
 - Come up with preliminary 53MHz cavity design that meets beam-loading and beam power requirements.
 - Initiate second harmonic cavity design (106MHz).
 - Come up with a feasibility study of coating the MI beam pipe with Titanium nitride for suppression of electron cloud.
 - Continue with e-cloud simulations in MI. Compare the predictions of the two e-cloud generation codes (POSINST, ELOUD) with MI beam observations and measurements.



Example Project X FY08 Goals



- Civil Construction
 - Review existing conventional facilities requirements and conceptual design for alignment with Project X scope and update
 - Prepare RFP for Architect/Engineer Consultant Services
 - If M&S available , begin comparison review of ILC and Project X main linac process cooling systems
- Cryogenics
 - Begin Component thermal modeling
 - Begin over pressurization modeling
 - Specify Cryogenic Instrumentation
- Controls
 - Software requirements: Expand existing requirements document to include input from machine and support departments.
 - Hardware Requirements: Develop hardware requirements, Survey existing hardware in MI/recycler/NUMI against Project X era requirements and develop plan.
 - Timing system specification: Specify protocol for controls timing signals in the project X linac and how this interfaces to the existing complex. Should include list of required modules but no actual design.



Project X FY08 Labor Needs

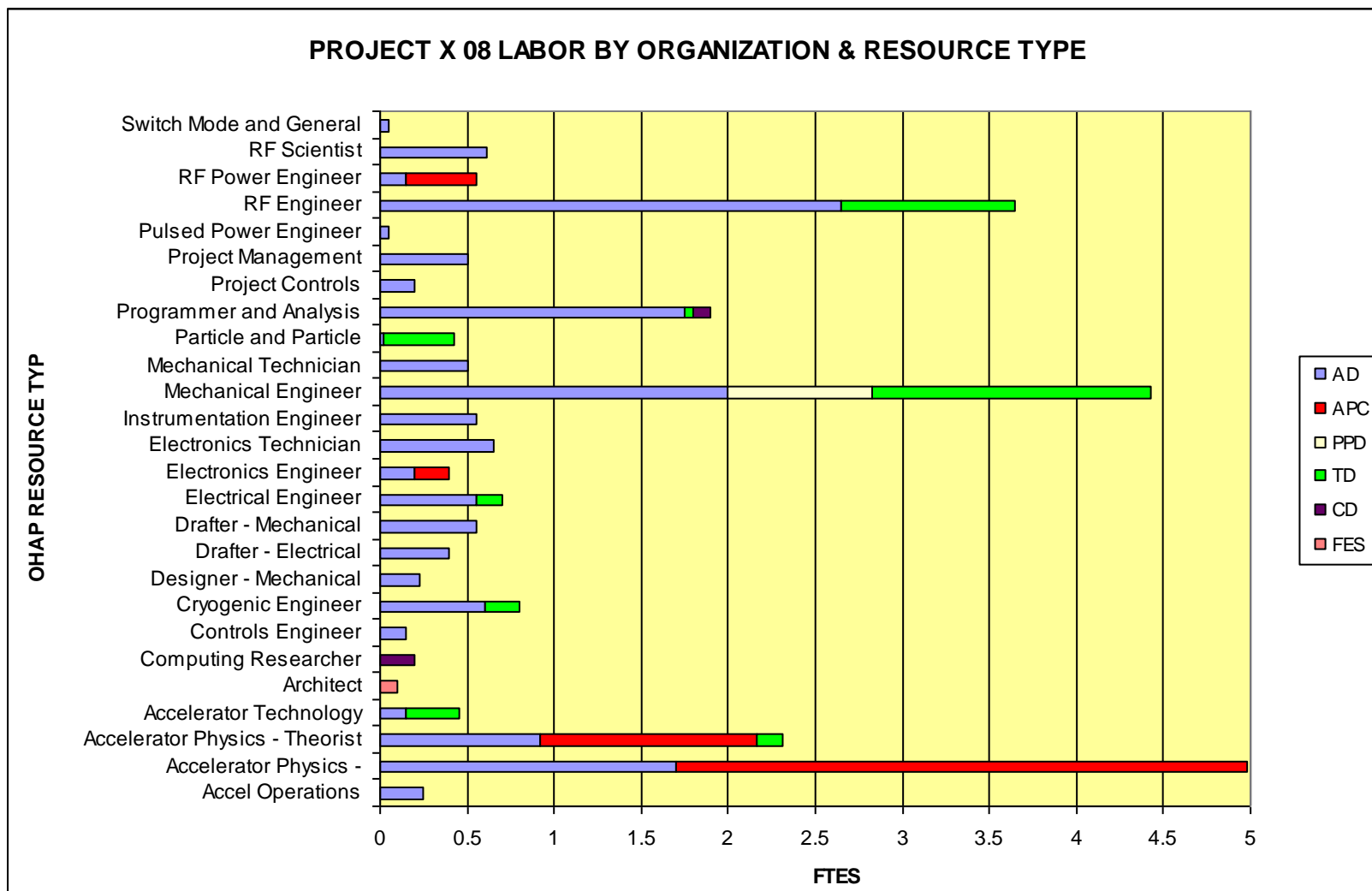


- Sample of resource summary information derived from WBS:

						Resource name	Department	OHAP resource type	% effort	Duration	FTE	
1	4					8 GeV H- Transfer Line and Injection						
1	4	1				R&D and Conceptual Design						
1	4	1	1			Project Management						
1	4	1	1			High-level Resource Loaded Schedule Development						
1	4	1	1				D Johnson	APC-HINS	Accelerator Physics - Experimentalist	5%	6	0.05
1	4	1	2			Physics Design						
1	4	1	2	1		Transport Line						
1	4	1	2	1		Create viable transport line and interface to injection SS and injection absorber.						
1	4	1	2				D Johnson	APC-HINS	Accelerator Physics - Experimentalist	42%	3	0.21
1	4	1	2				M Xiao	AD-Recycler Department	Accelerator Physics - Theorist	50%	2.5	0.21
1	4	1	2	1			A Parker	AD-Mechanical Support	Designer - Mechanical	25%	2	0.08



Project X FY08 Labor Needs

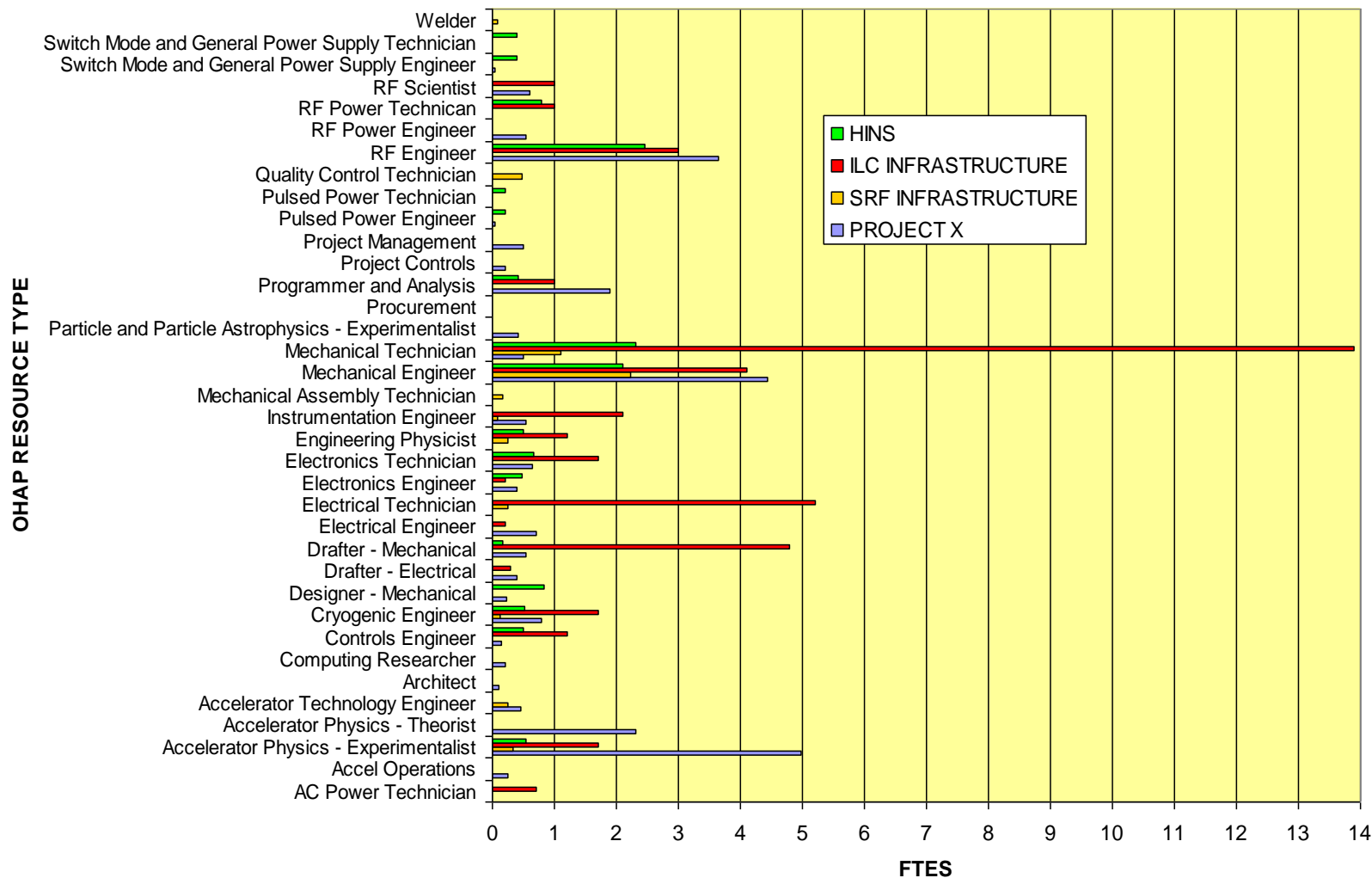




Combined 08 Labor Needs



08 LABOR BY PROGRAM & RESOURCE TYPE

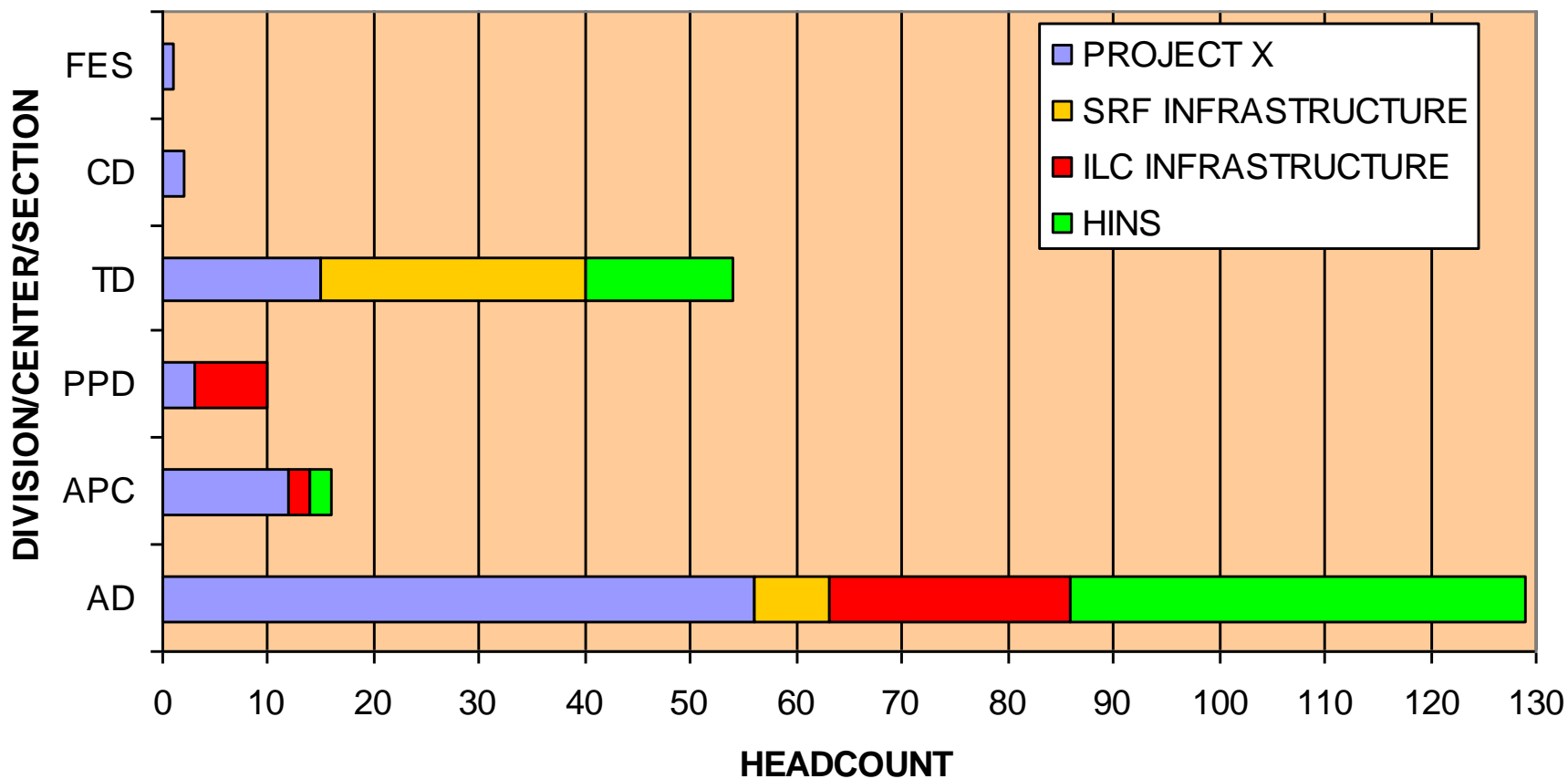




Combined 08 Labor Needs



COMBINED 08 HEADCOUNT LABOR BY ORGANIZATION





Summary



- The general requirements of Project X are defined
- From the general requirements:
 - The scope of Project X is defined
 - The requirements of the technical subsystems are derived
- The system requirements drive the design and development plan goals.
- A RD&D team was assembled to formulate and execute the design and development plan.
- For FY08, specific goals for each sub-system have been defined.
- The resources required to accomplish these goals have been defined.



Summary



- From the Directorate, we need:
 - Approval of the Project X general requirements
 - Approval of the FY08 RD&D plan goals
 - Approval of the Fermilab RD&D Team.
 - Understanding of the resource requests
 - Permission to execute the RD&D plan.
- The next steps are to:
 - Present the resource needs to the Fermilab Division Heads
 - Work with the to Fermilab Division Heads to organize the required resources.



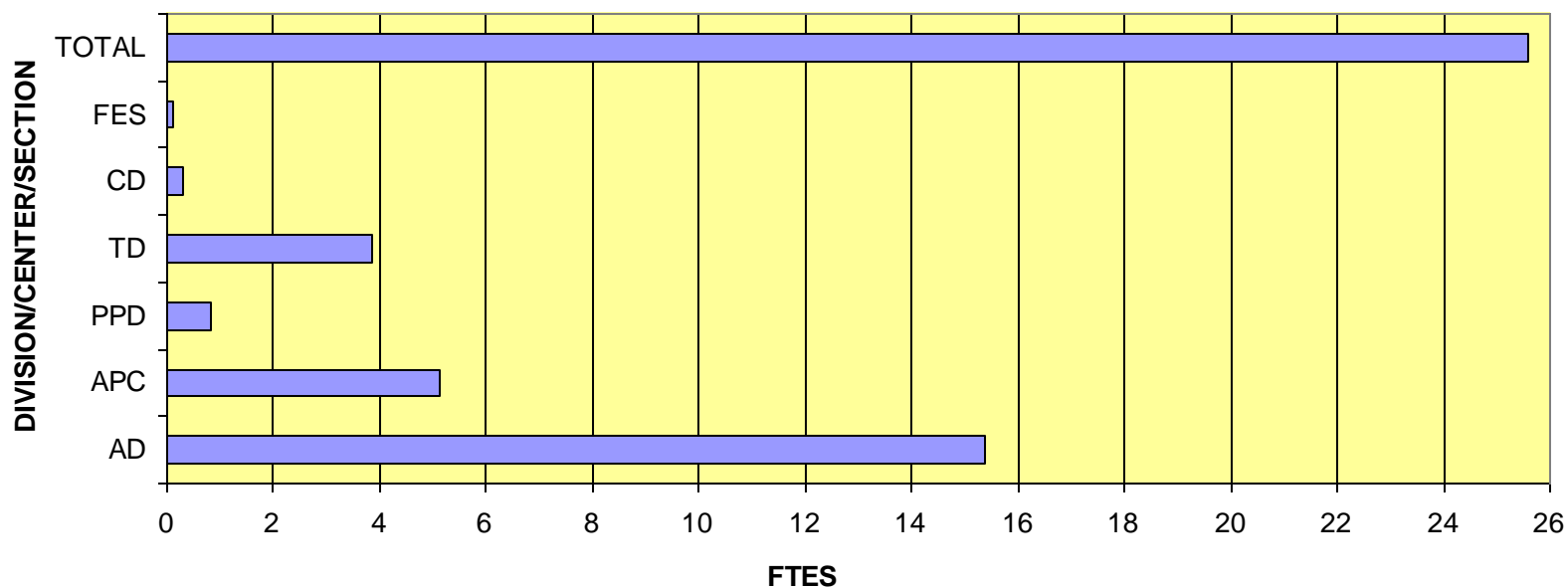
BACKUP SLIDES



Project X FY08 Labor Needs



PROJECT X 08 LABOR BY ORGANIZATION

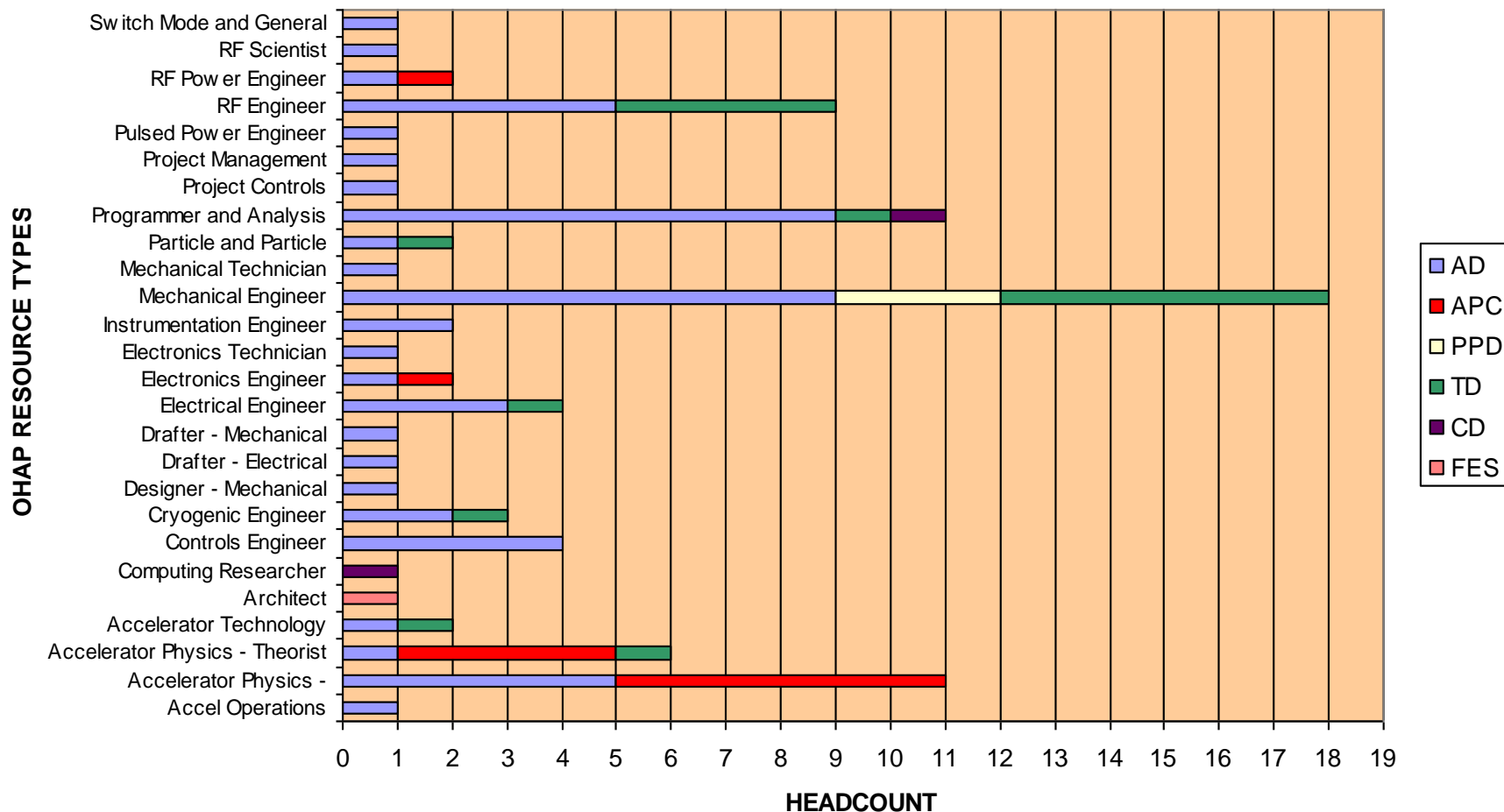




Project X FY08 Labor Needs



PROJECT X 08 HEADCOUNT LABOR BY ORG & RESOURCE TYPE





Project X FY08 Labor Needs

